Cryogenic and Vacuum Compatible Metrology Systems

2012 SBIR Phase I Project

1 August 2012

Mirror Tech Days – Rochester, NY

Prepared by:

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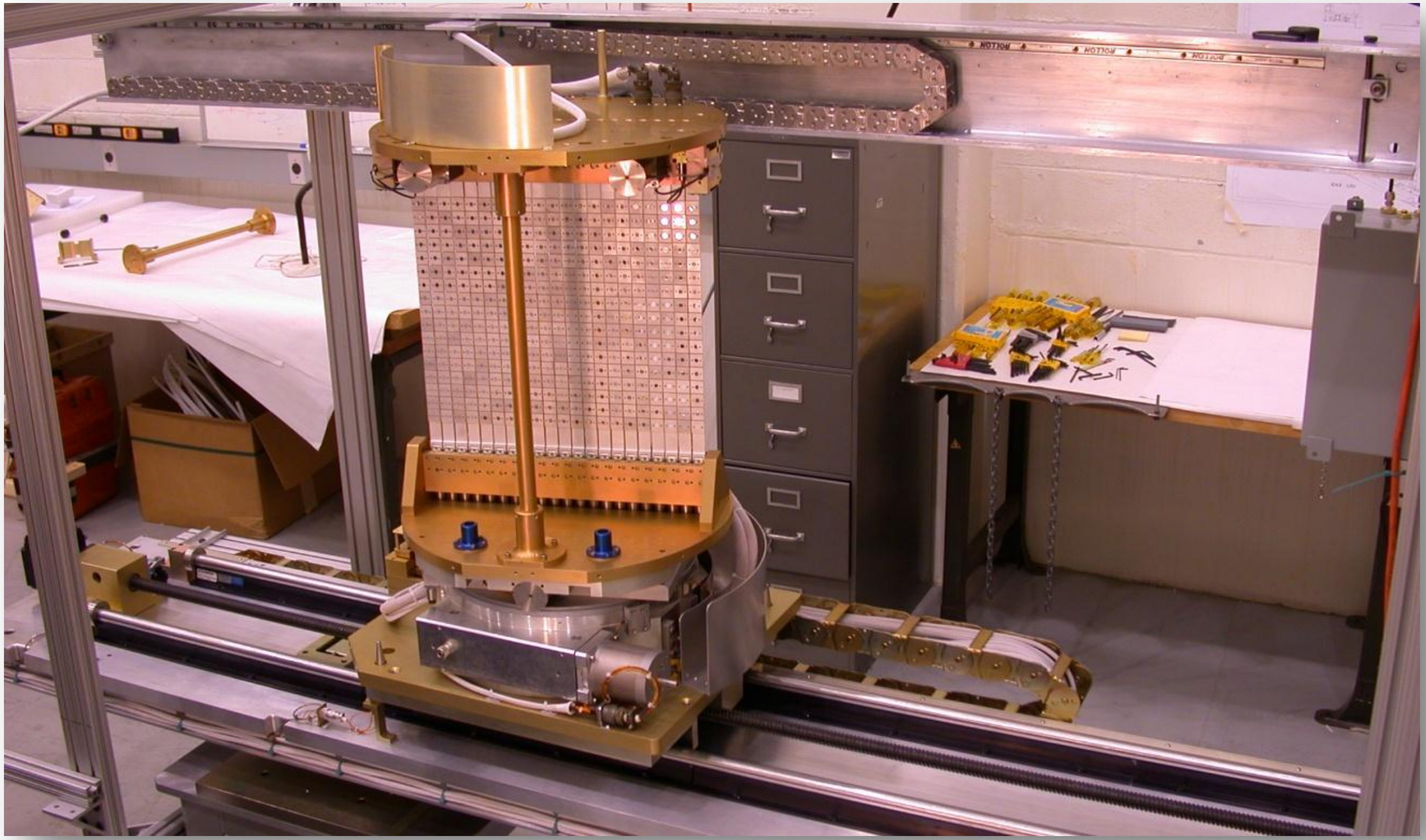
President

Flexure Engineering

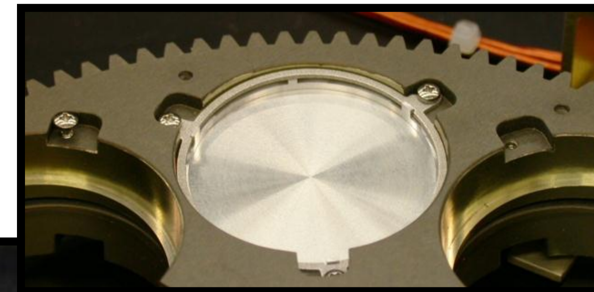
Started at Johns Hopkins …

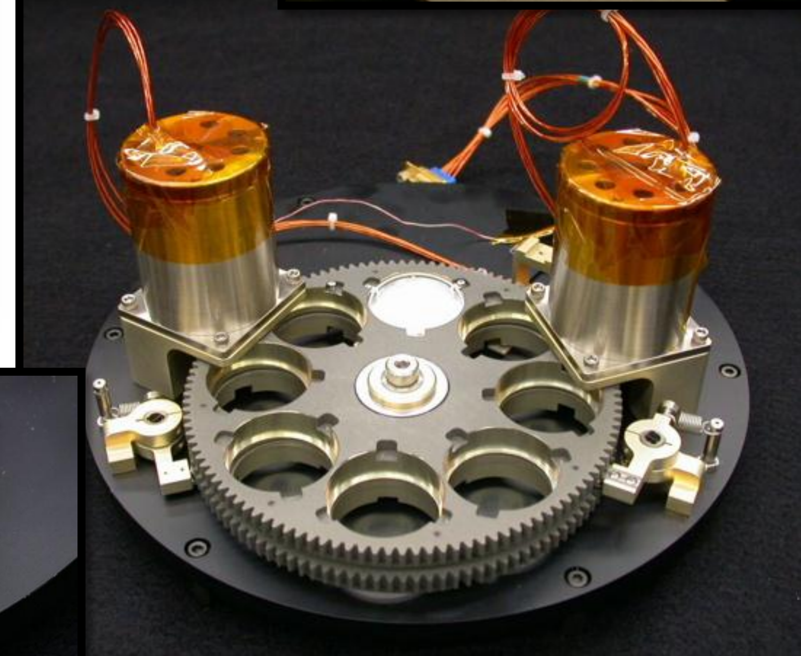
- Radiation-hardened Neutron Monochromator @ JHU

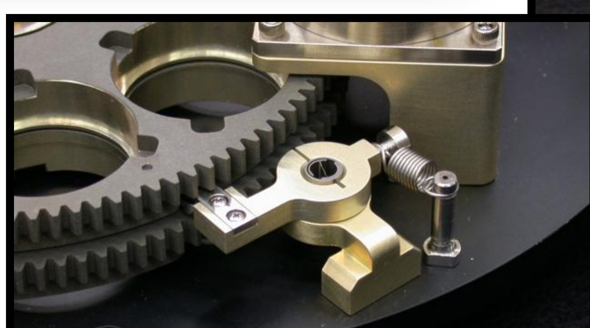


CryoVac Engineering

80K IR Camera (WIYN WHIRC) @ JHU

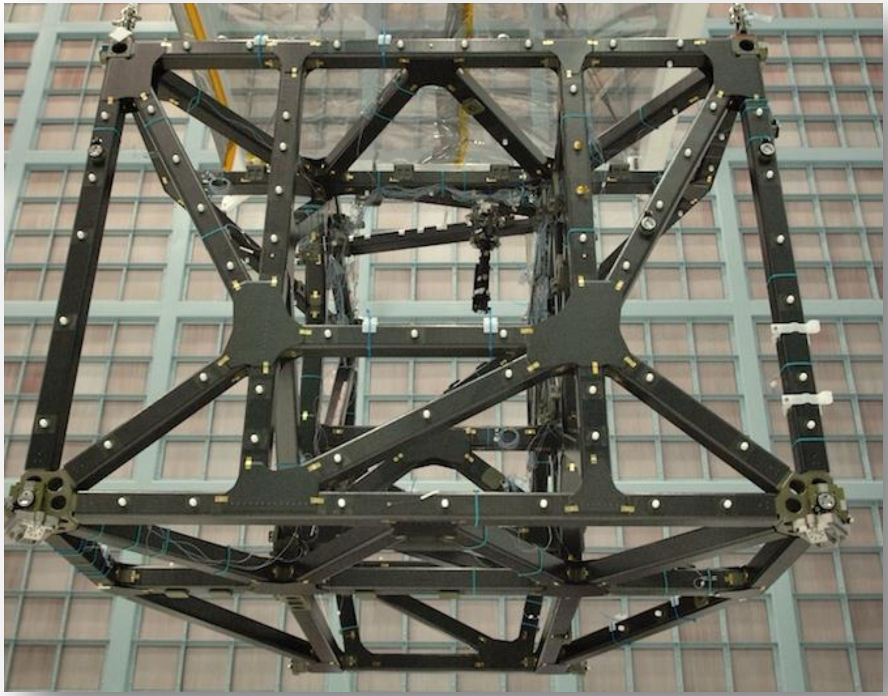






CryoVac Opto-Mechanical Systems

- **JWST … 30K Engineering**
  - Opto-mechanical designs
  - Cryogenic Calibration



Flexure's Customer List

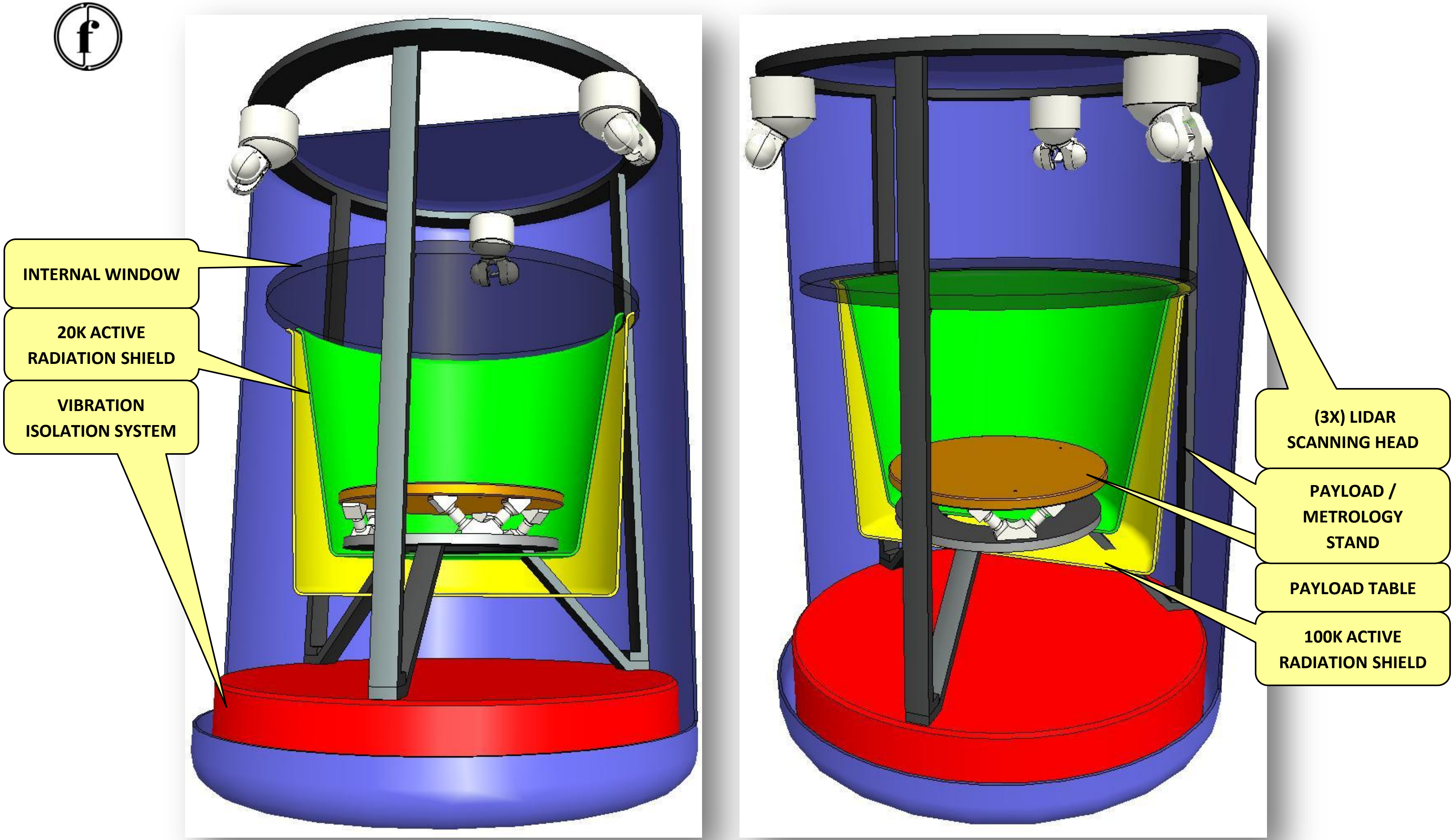
- NASA JWST (NIRCam, ISIM), MMS, ICESat-II
- NASA SBIR Program
- QinetiQ North America
- Oceaneering
- NIST
- Brown University
- Advanced Magnet Lab
- Micro Aerospace Solutions
- ASU Biodesign Institute

Purpose of Our Phase I Project

- To create a cryogenic and vacuum compatible LIDAR scanning head (LSH), integrated to a thermal-vacuum chamber, that can produce better than 5 micron, 3 sigma, measurement uncertainties on optical structures and systems at a range of 10 meters, in high vacuum, and at temperatures down to 20 Kelvin.
- To identify two metrology instruments that can leverage the technology of the cryo/vac LSH and extend the capabilities of in-situ, cryogenic metrology.
- ***Technology Innovation: DeepCryo Actuation, Knowledge, and Control***

We define "DeepCryo" as an environment whose room temperature is below 100K (-173 deg C / -279 deg F).

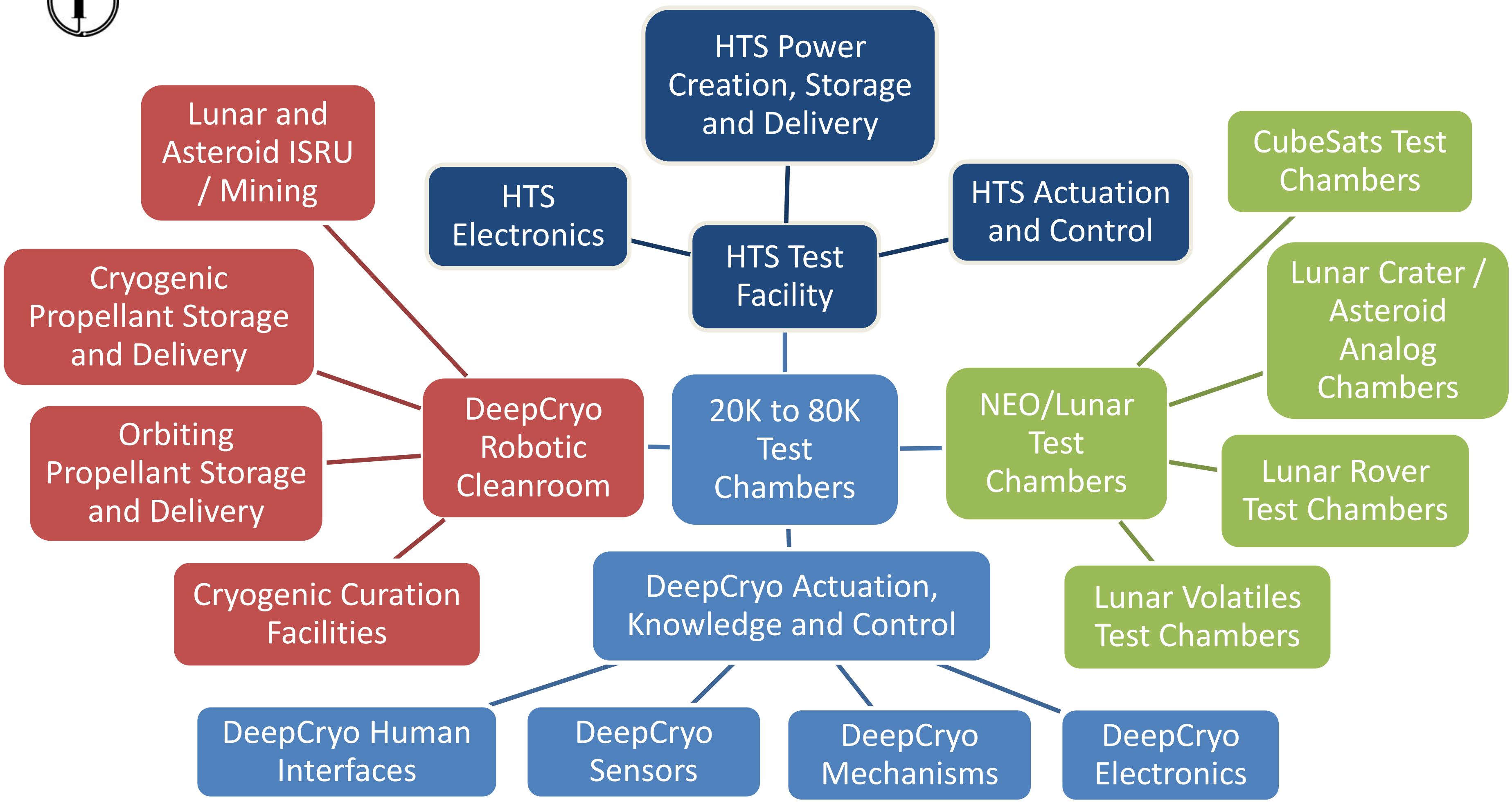
Multi-headed Metrology System



Applications of Our Innovation …

- NASA
  - JWST, WFIRST, NEO Missions [ISRU] to Cryogenic Destinations (Lunar Poles, Asteroids)
  - In Situ measurement of large structures in thermal-vac chambers (non-cryogenic, cryogenic)
- Non-NASA / Commercial
  - Superconducting Innovations for Renewable Energy (HTS Wind Turbines, HTS Flywheels)
  - The Navy's All-Electric Ship (requires large cryogenic volumes for superconducting power creation and storage)
  - Cryogenic Data Centers
  - Other Extreme Environment Facilities (Beryllium manufacturing, Salt Water Test Facilities)

Technologies and Facilities



Current Cryogenic Systems

The state-of-the-art in space environment simulation does not offer truly DeepCryo and vacuum compatible actuation, knowledge, and control.

- *DeepCryo: an environment where the room temperature is below 100 K*
- Current technology solves the vacuum problem, but only marginally solves the cryogenic problem … ***<u>as a system</u>***
- NASA Projects are challenged to take the cryogenic problem head-on due to cost and schedule. Therefore work-arounds are typically implemented.
- In order to truly solve the cryogenic problem, it must be given the proper venue … A Research and Development Project (such as SBIR/STTR) is better suited to begin solving the DeepCryo problem.

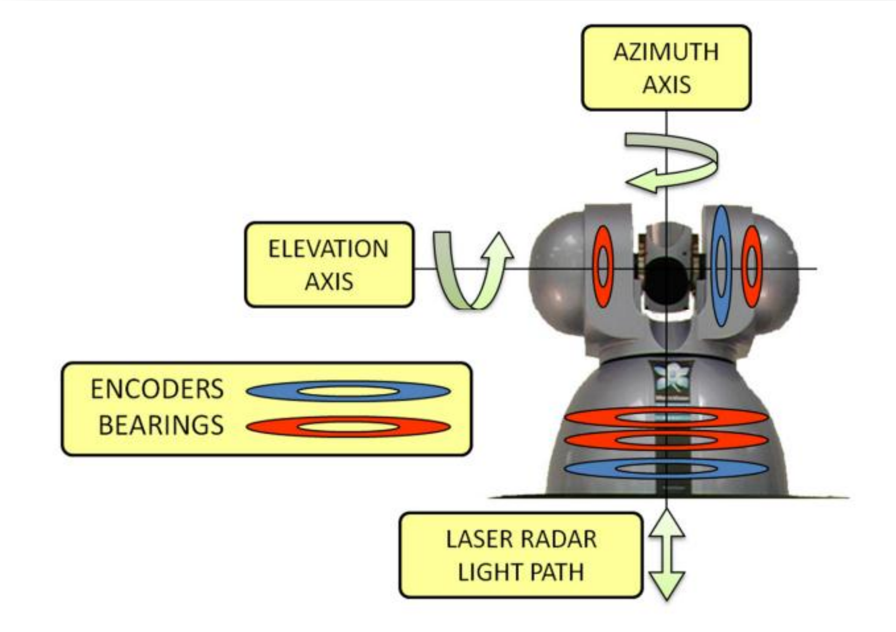
Path to All Cold Systems

- Achievable solutions include systems that operate at higher cryogenic temperatures (220K+, i.e. mil spec COTS)
- Building hardware operable at 220K begins the long-term development path to engineer complete, DeepCryo and vacuum compatible systems.
- Continued development and funding will then bring the operating temperatures down to our target of 20K.

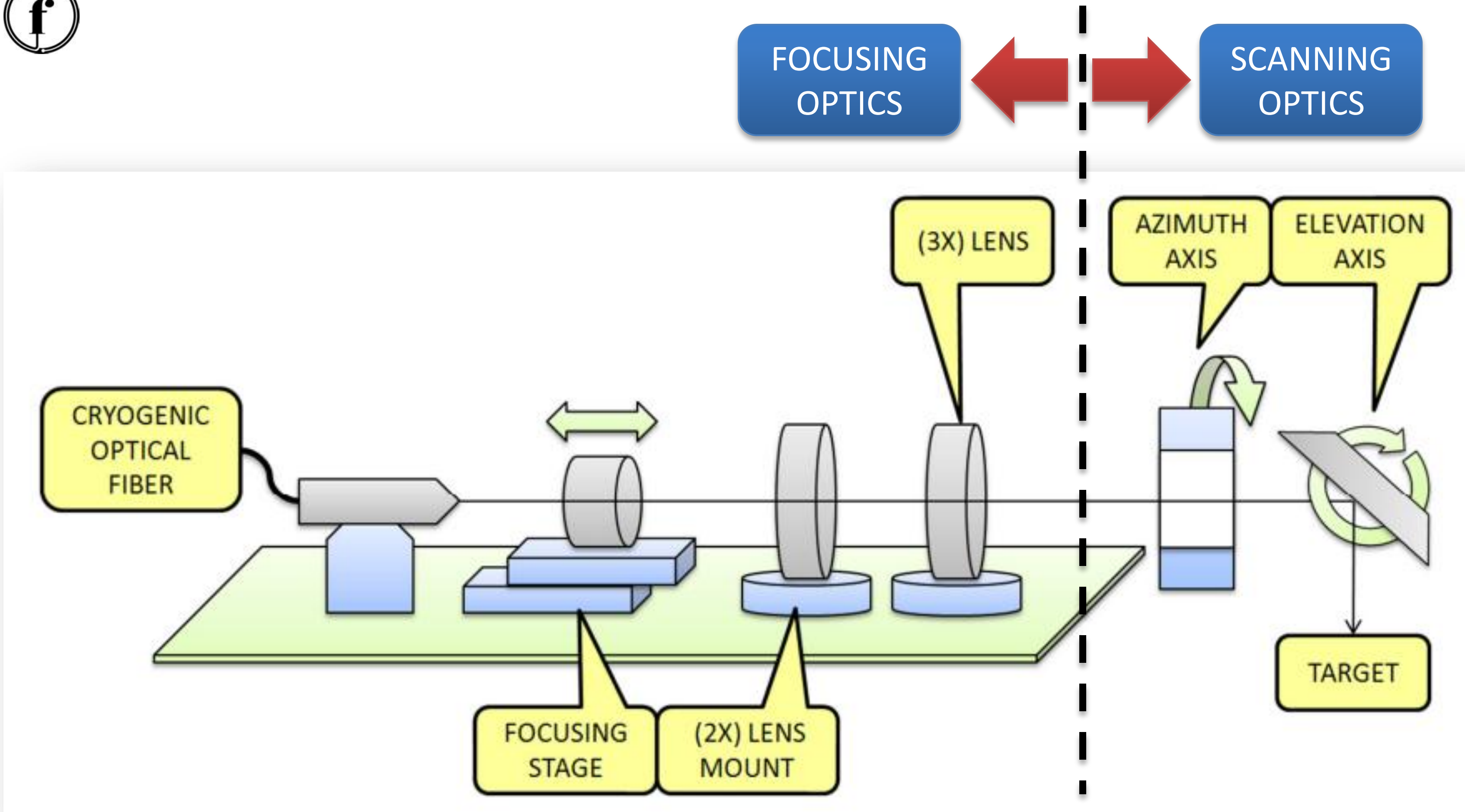
Essential design note: Any DeepCryo, All-Cold System, must start at about 300K (perhaps 350K to 400K for a bake-out) and "travel along the temperature dimension" until the system arrives at its operating DeepCryo destination.

Laser Radar

- Non-contact metrology
- Direct measurement of hardware surface
- 75 mircon uncertainties for a 10m range
- Not cryo or vacuum compatible

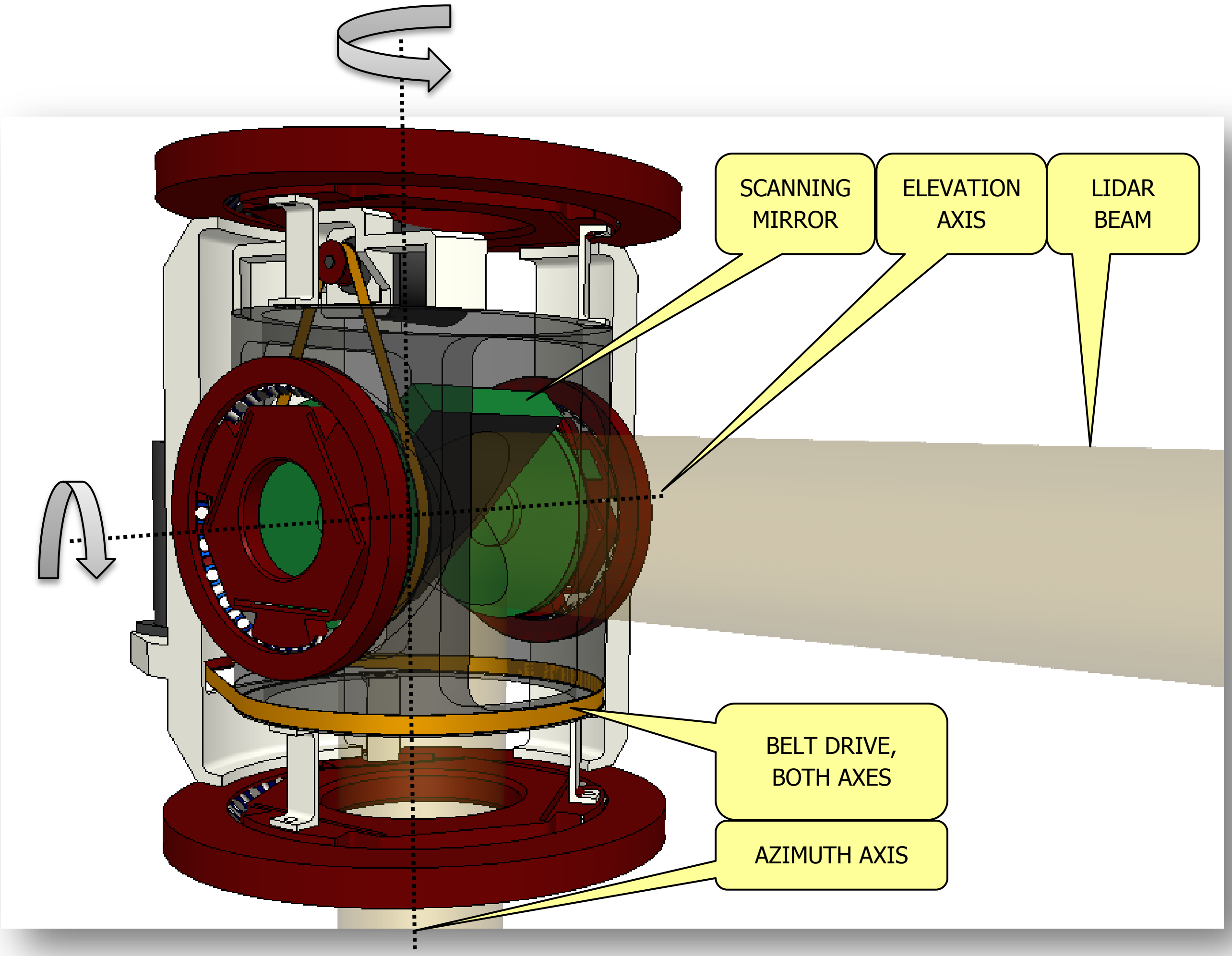


Schematic of LSH



LIDAR Scanning Optics

Conceptual Design from Flexure's 2011 SBIR Phase I



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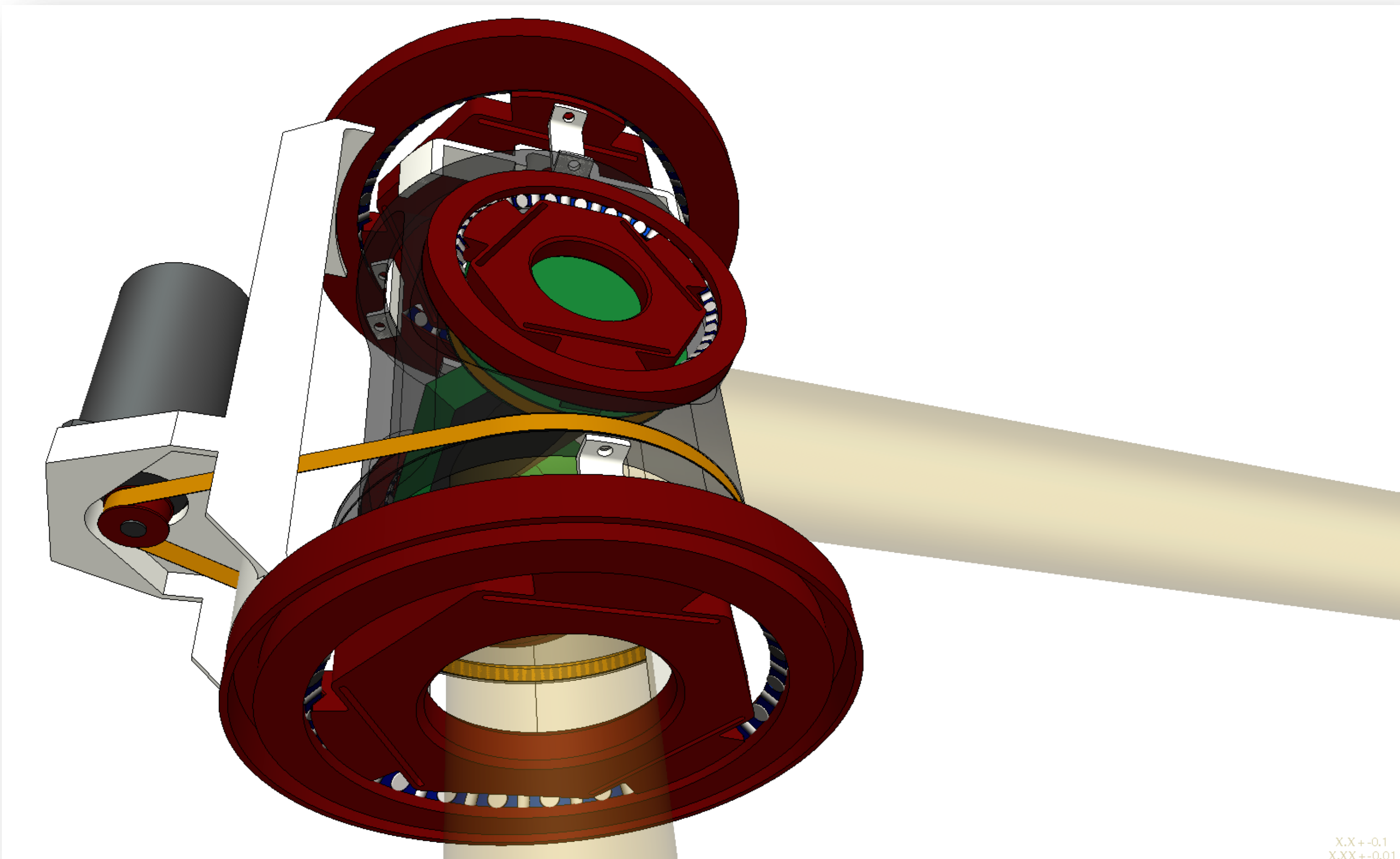
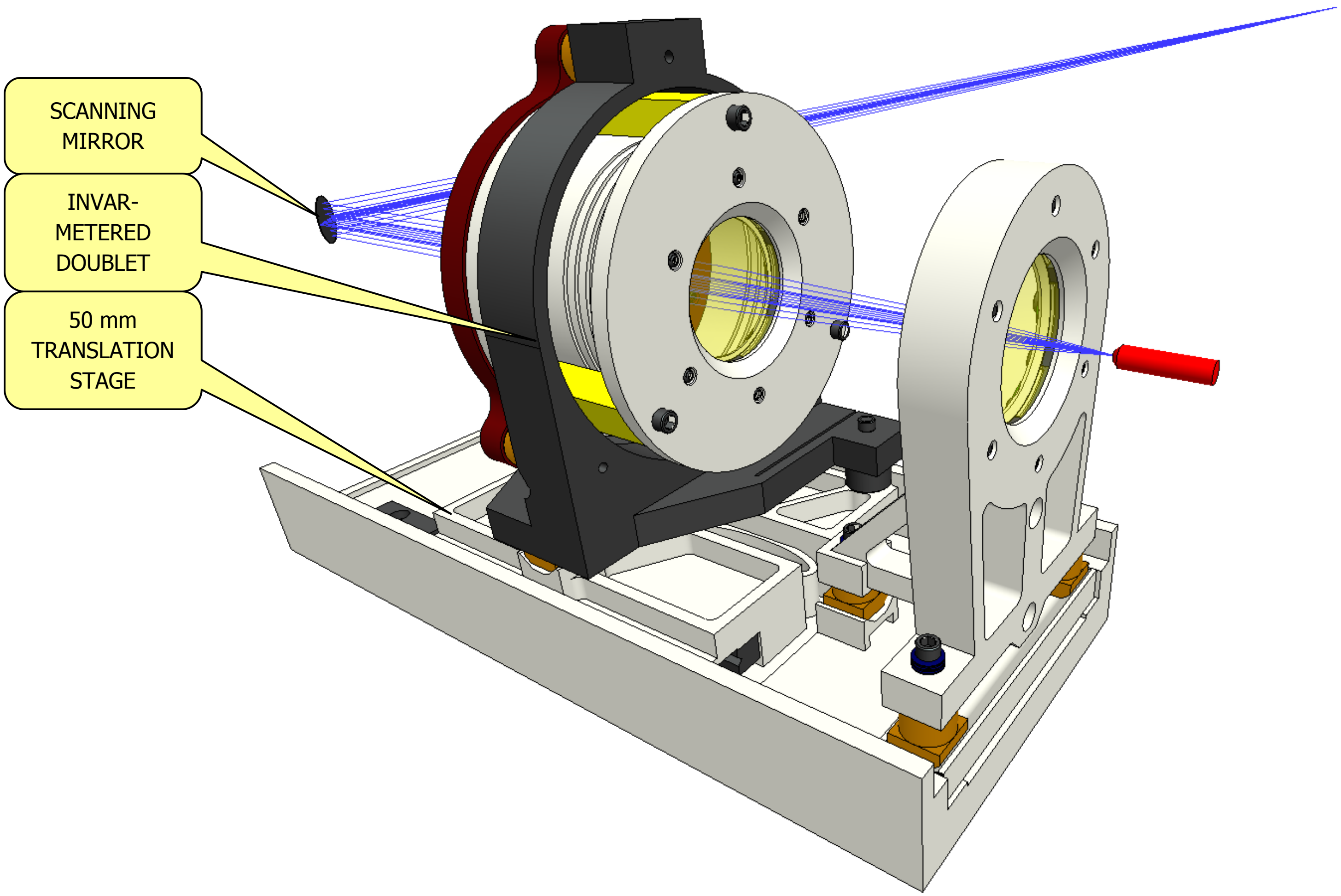


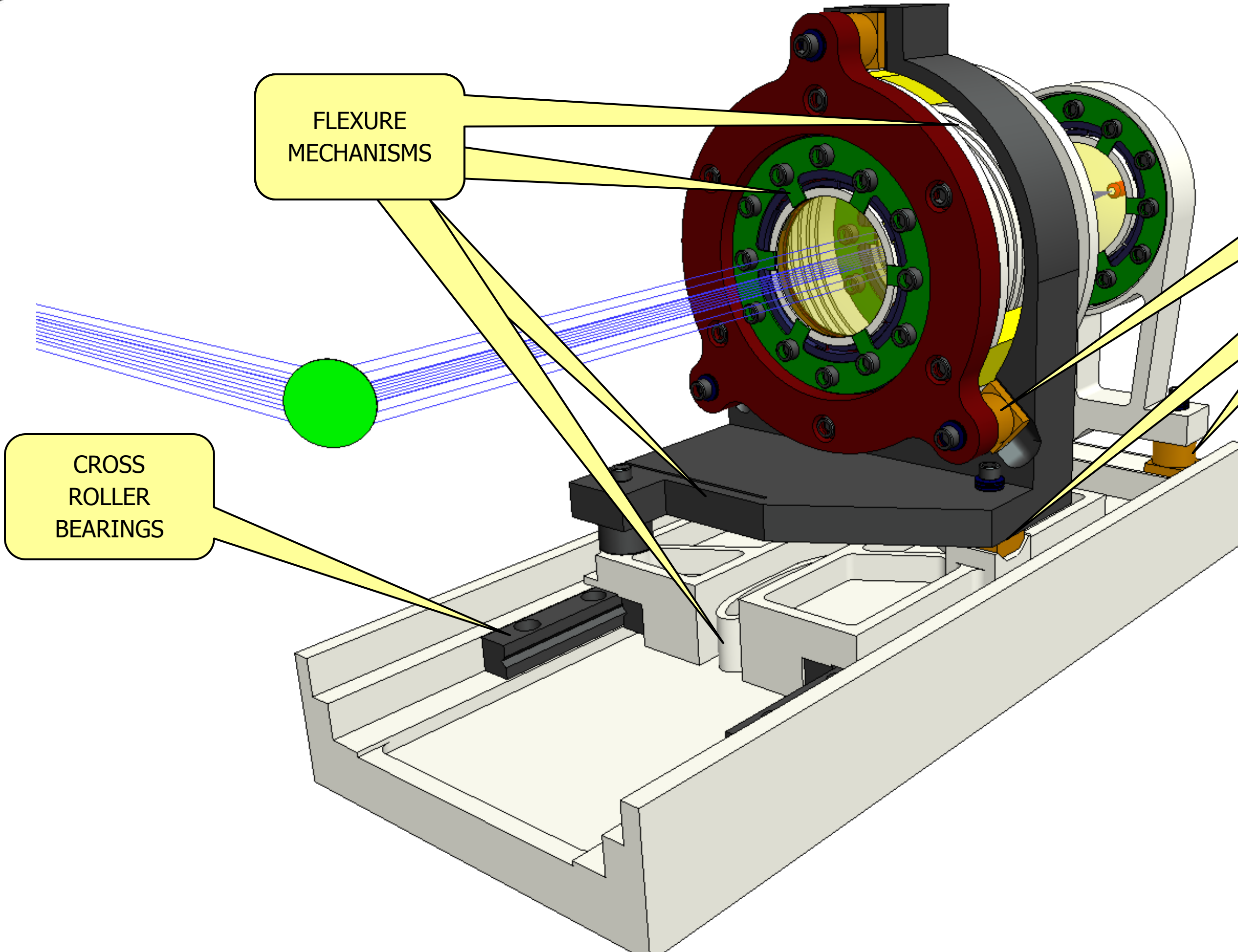
LIDAR Focusing Optics

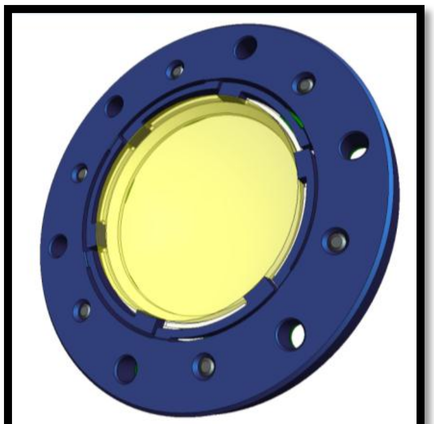
Designed for 20K Operation



LIDAR Focusing Optics

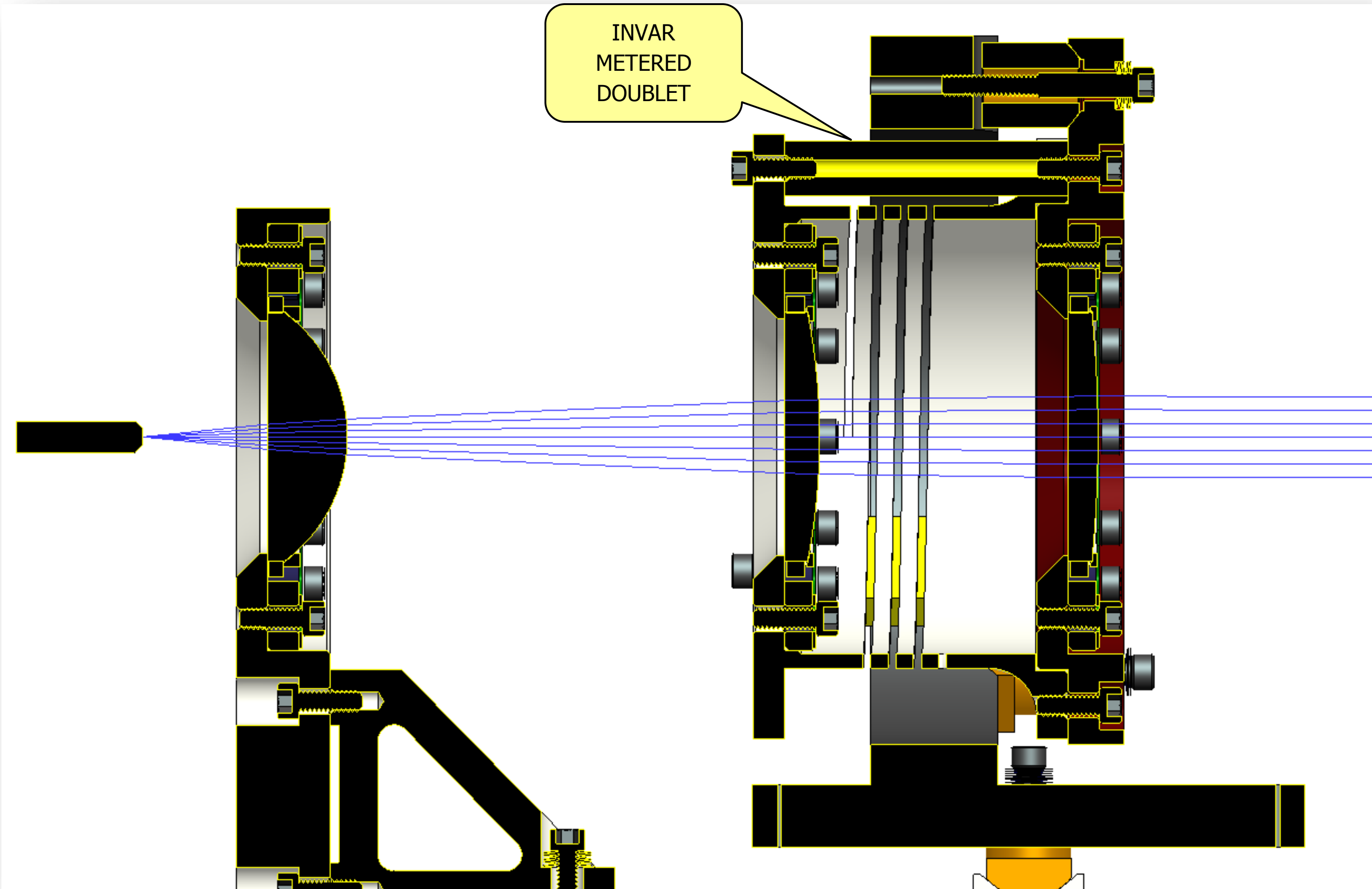
Designed for 20K Operation





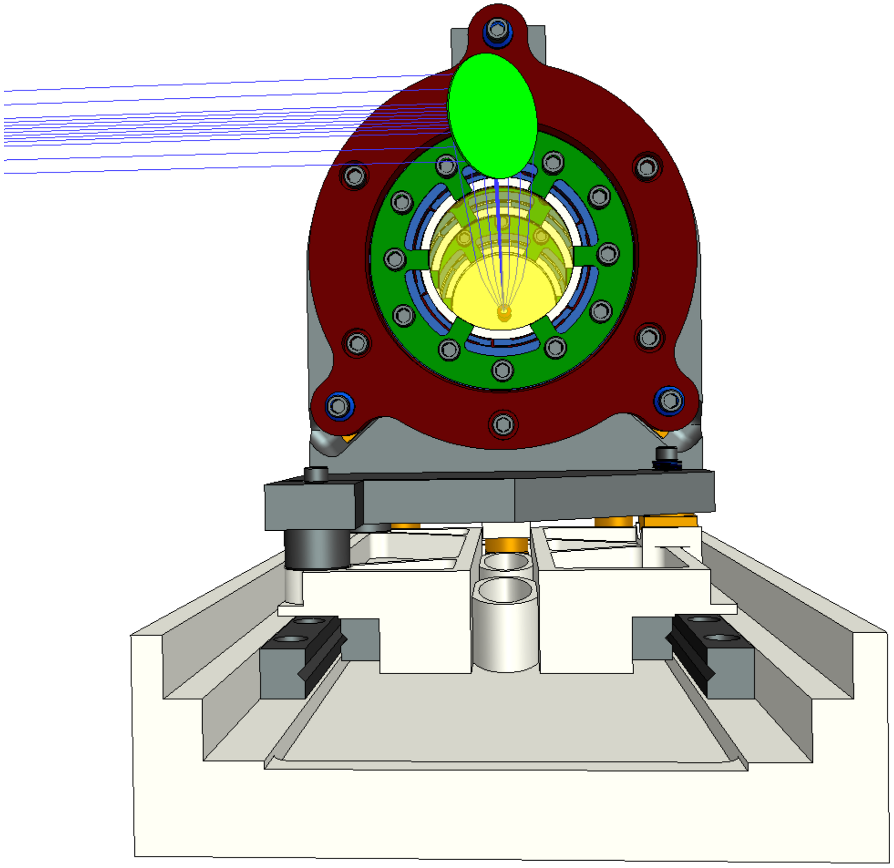
LIDAR Focusing Optics: Cross Section

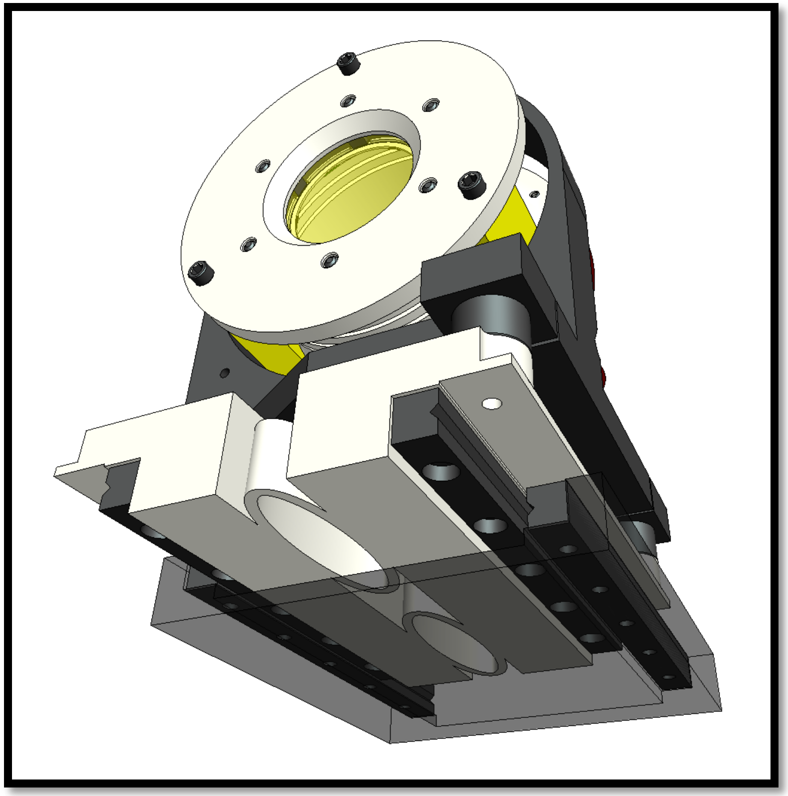
Designed for 20K Operation



LIDAR Focusing Stage

Designed for 20K Operation





Phase I / Phase II Activities…

- Phase I:
  - Integrate Scanning and Focusing Optics Assemblies
    - Add motion control and positional feedback
  - Flexure mechanism analysis
  - Baffling / Coatings
  - Venting / Light-weighting
  - Complete Error Budget for single LSH
- Phase II
  - Thermal Analysis and Design
  - STOP Analysis
  - Multi-Headed Error Budget (trilateration)
  - ETU Fabrication and Testing

Encoders from BEI

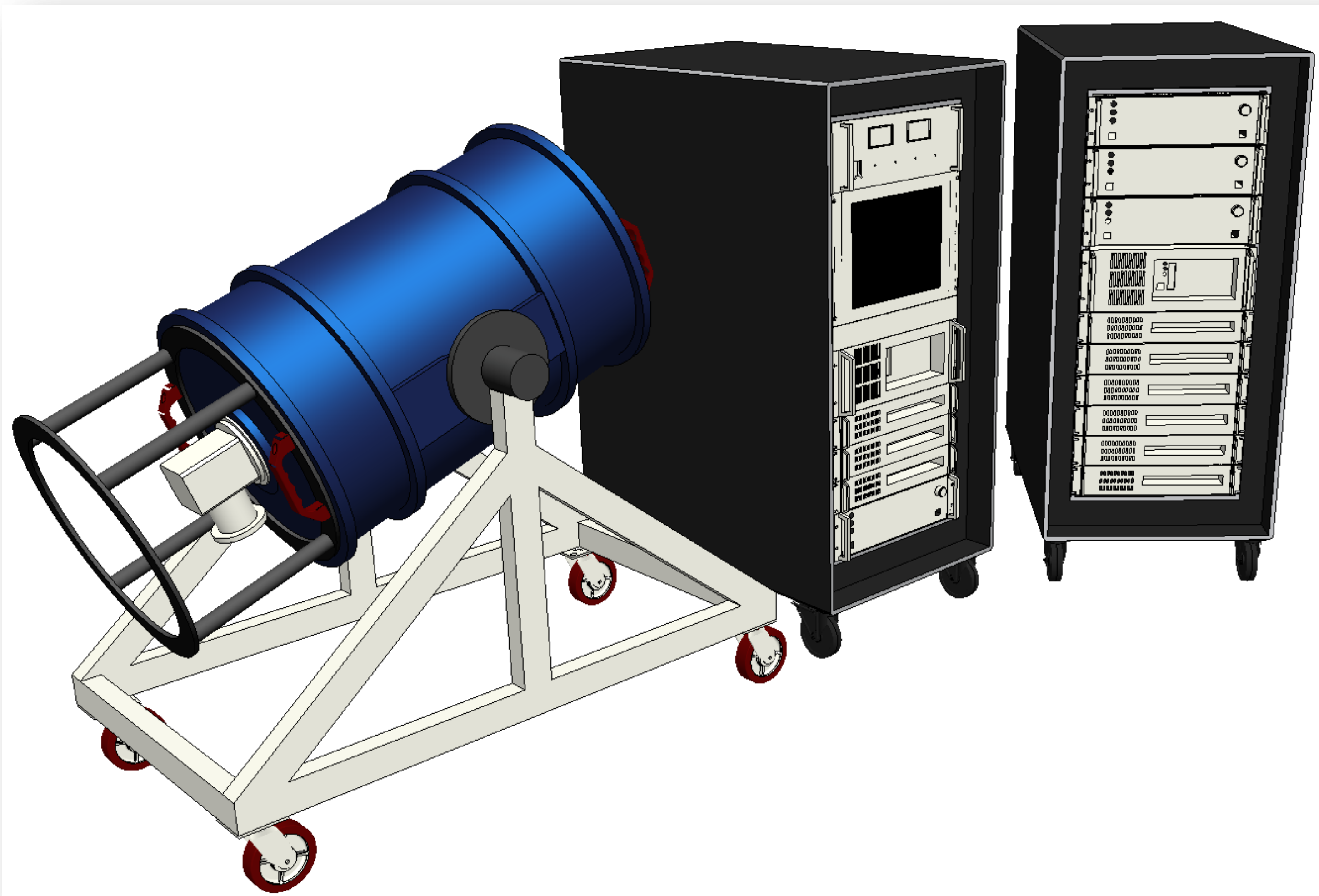
*nano*Series® Family

- 24-bit Resolution
- Vacuum Compatible
- Operates down to -55 degrees C [218 K]
- First Step: separate head from electronics

The Mobile Chamber

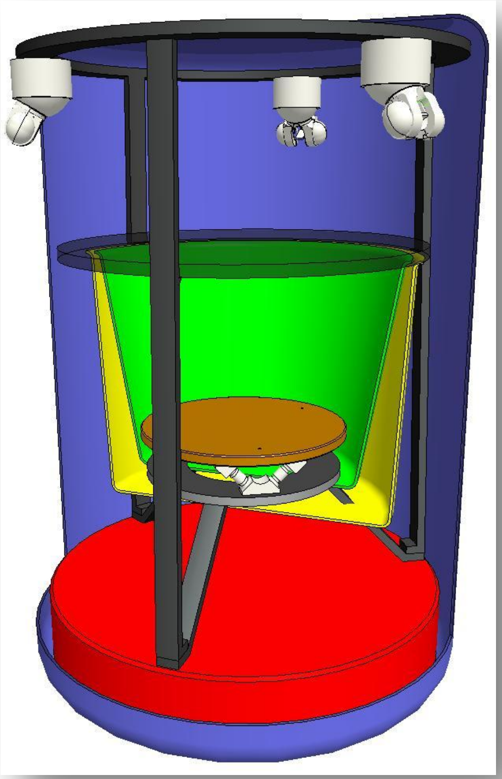
- Customized and modular thermal-vacuum metrology system
- Creates the shortest path to science by integrating the required metrology instrumentation with The Mobile Chamber.
- A leasing program for Project's provides following benefits:
  - Offload the cryogenic engineering work and start with a working chamber.
  - More easily upgrade or downgrade the chamber based on changes in testing requirements
  - Rely on Flexure's extensive maintenance program to make sure The Mobile Chamber stays functional.

The Mobile Chamber



The Path Forward …

- **<u>Phase II Opportunities</u>**
  - Encoders / Motion Control
  - STOP Analysis
  - Multi-Headed Error Budget (trilateration)



Proposal Due: *<u>23 August 2012</u>*